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Working outside the BOX

On their own time and with no funding, some creative engineers at Compaq came up with a design for a new server. The skunkworks project is now a multi-million dollar global business.

Karen Auguston Field, Chief Editor

Marlborough, MA—Engineers sometimes joke that the real way to get a product developed quickly and cheaply is to cancel the project. That was literally the case for a team of self-described "rogue" engineers at Compaq, who willed the AlphaServer DS10L ultra-thin, high-speed server into existence after the initial proposal and funding request had been rejected.

Engineering Manager Richard Dischler and Systems Engineer Mike Rolla came up with the idea for the new server by looking at where the market was going for products like the company's AlphaServer DS10, a powerful, high-speed server based on the 64-bit Alpha microprocessor. It is designed for floating-point intensive tasks, such as computer animation, that can be partitioned among multiple machines to achieve higher throughput.

"We knew there was a market out there looking for pure processing power at a lower cost than the DS10. Basically all some people want is a CPU, with none of the extra stuff around it," says Dischler.

Size matters. Dischler and cohorts Rolla and Mechanical Engineer Jeff Lewis began thinking about how they could reduce the size and cost of the original AlphaServer currently under development, while still offering the power that customers craved. They figured if they could reduce the 3U (5.25-inch) height of the DS10 by two thirds to create a 1U (1.75-inch) tall machine, they could fit an unprecedented 40 machines in a single rack. By also reducing the amount of memory and offering fewer bells and whistles, they'd have the ideal low-cost, high-density server.

Although management at Compaq initially declined to fund the project so that engineers could focus 100% of their efforts on the about-to-ship DS10, they didn't discourage work on the DS10L. "There were a few winks as we were being told to stop work," recalls Rolla. In fact, engineers say that Compaq's culture actively encourages skunkworks-type projects.

Having no funding and working on their own time, the team knew that if they were to be successful they would have to leverage as much as they could from the DS10 and other products. "Our goal was to prove we could use the existing Alpha motherboard, and steal

Working clandestinely after hours, the engineers who developed Compaq's AlphaServer DS10L computer even rummaged through company dumpsters at night, searching for spare parts to use in prototypes. Left to right: Systems Engineer Michael Rolla, Engineering Manager Richard Dischler, and Mechanical Engineer Jeff Lewis.

and borrow from other programs in order to cobble up a low-cost, high-performance 1U Alpha machine," says Rolla.

That decision turned out to be both a blessing and a curse. The benefit of using a common motherboard was that it minimized risk and qualification efforts by allowing engineers to use a subset of the already qualified DS10 peripherals. And since the two boards would be identical (with the exception of two items installed at final assembly), manufacturing would essentially have to build just one board instead of two.

But the fact that the DS10's motherboard design was essentially frozen meant that the team working on the new server had to be really, really creative. "To get to 1U, all components taller than 1.75 inches had to be redesigned (see chart), including memory DIMMS, which are 1.755 inches tall," says Rolla.

Similarly, they had to squeeze the height of the power supply down from 3.4 to under 1.75 inches. Helping matters was the fact that it would only need to generate just 150W, as opposed to the 300W power supply used in the DS10. "At 1.6 inches tall and just 74 cubic inches, the new power supply is tiny. Since we budget about 25W per PCI option, it really helped that we were offering just one option instead of four," says Power Supply Engineer John Arduino. With no funding to develop a power supply from scratch, Rolla tackled the problem by scouring the Internet for vendors. Incredibly, Rolla found a power supply that required only minor modifications.

To see a video of this technology go to **designnews.com**

Chilling out. The biggest challenge by far, however, was thermal management. Given the low profile of the box and tight 1U spacing of units in a rack, Thermal Engineer Bob Sullivan and Acoustic Engineer Bob Hellweg wondered how they would get rid of all the heat generated by the powerful Alpha CPU chip. Not to mention avoiding a design that would sound like a 747 taking off. The chip dissipates 74W at 616 MHz; a full rack of 40 units dissipates more than 8,000W.

Using the existing blower/heat sink, which stands 2.75 inches high and requires an additional 0.5-inch clearance for airflow, was out of the question. "Had we been able to change the configuration of the motherboard, we would have

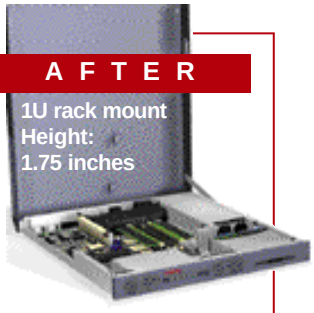
Compaq slims down a server

BEFORE

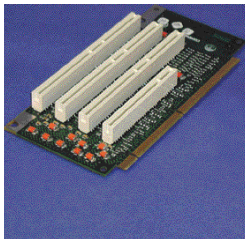
3U rack mount
Height:
5.15 inches

AFTER

1U rack mount
Height:
1.75 inches

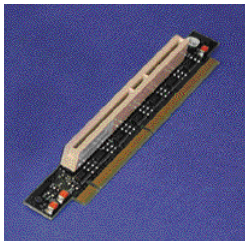


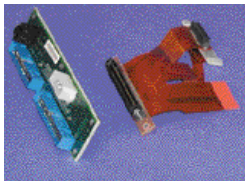
In order to leverage the existing DS10 design, engineers had to figure out how to fit everything into a box only one third the height of the original.



PCI riser card

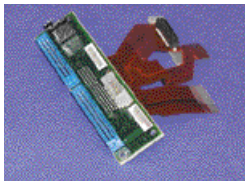
The original 4-slot PCI riser card would not fit in the DS10L enclosure. Although a one-slot PCI riser fit, engineers needed a cross-member support structure to brace the card. Mechanical Engineer Jeff Lewis solved this problem by designing a unique plastic stiffener, which anchors to the CPU heat sink. It supports the riser card and allows insertion of a PCI option without any resultant damage to the riser card or the connector on the motherboard. Engineering Manager Richard Dischler also came up with a memory riser card that allows memory DIMMS (which are 1.755 inches high) to be mounted sideways.





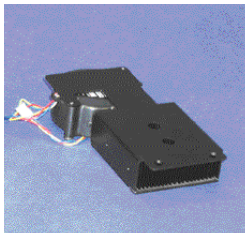
Adapter module and flex etch

With no room to accommodate the existing parts, Systems Engineer Michael Rolla combined two separate components in one space-saving part. Since both components had already been qualified on prior products, all he had to do on this low-risk design was pull up a new part number and mark up existing schematics and drawings.



CPU blower/heat sink

The CPU blower/heat sink on the DS10 is 2.75 inches tall and requires a 0.5-inch clearance for airflow. Engineers had to design a smaller new heat sink that would dissipate the smaller heat generated by the close spacing of units. The solution was a more compact, lower-profile heat sink with a greater surface area, closely-packed convoluted fins, and a side-mounted blower. Engineers also added convective cooling by locating three 40mm fans at the front of the unit that build up pressure and one 40mm exhaust fan at the rear. Airflow baffling channels air into the blower/heat sink, ensuring that the blower does not recirculate on itself and ingest hot air.



had more flexibility in terms of thermal management," says Sullivan. "Given the constraints, it was necessary to use closely packed fins on the CPU heat sink in conjunction with a small, powerful blower to force air through it.

In the new cooling system, three front-mounted fans build up pressure inside the box while one rear-mounted fan exhausts the air. An airflow baffle on the patent-pending CPU heat sink ensures that the blower does not recirculate on itself. To further improve heat transfer, the top of the CPU has a copper-tungsten heat spreader with two studs. The heat sink, which has a machined surface flatness of 0.005 inch, is bolted to the package with a torque of 20 inch-lb. A thin sheet of thermally conductive grafoil is sandwiched between the blower and the heat sink.

To make room for a full-length PCI card, engineers removed the heat sink from the CPU regulator and placed a black label on it. This label primarily provides PCI-to-regulator "short circuit" protection. Through "fan fail" condition (limited airflow) testing, Sullivan found that the label also increased the surface emissivity of the CPU regulator, lowering the surface temperature an additional 4C via natural convection. With 40 systems in a rack, engineers used flushing fans located in the rear of the cabinet to evacuate the hot air.

How to pull off a skunkworks project successfully

Here are some tips from the engineering team that developed Compaq's DS10L computer in the back room of their lab. Although the company provided no initial funding for the project, engineers say the environment at Compaq fosters innovation and creativity and rewards them for pursuing projects on their own time:

- Consider yourself freed from the constraints of corporate bureaucracy. With no one in the way to slow you down, you can engineer as you see fit, make instant design decisions, and work at your own pace.
- Choose the most talented, most experienced engineers for the team. Then hide them.
- Leverage existing resources, including current product designs, standard part numbers (Many of the parts on Compaq's DS10L are common to other products), friends in other departments, vendor relationships, test rigs, etc.
- Trust your intuition—you won't necessarily have the time or resources to do all the testing you would like to do.
- When you are ready to show management your creation, you can't just impress them—you've got to literally blow them away.
- Never, ever forget that failure is not an option.

A global product. The fact that engineers were able to meet all goals on this skunkworks project in less than a year and ultimately help to create a multi-million dollar business is all the more remarkable when considering the product's global reach. Not only did engineers have to design the DS10L to meet numerous international standards, many of the components inside are sourced from overseas companies (below).

Good relationships with vendors—wherever they were located—paid off in spades for the team, reaping such benefits as a reduction in lead times to build prototypes. Prescott says tooling changes on this project totaled only $25K—a drop in the bucket compared to the typical project.

Unbelievably, the team was able to keep the project on track, even with no hard dates on the schedule or formal team meetings early on. They did discuss the project during their regularly scheduled Monday meetings, but only to go over the nagging issues such as, "Still need to know if the disk overheats."

"To be successful, you can't bother people with the little things," says Dischler. "Leave them alone and let them do their job."

And for the engineers involved in this project, they wouldn't have had it any other way. "If squadrons of people had worked on this product, it probably would have taken twice as long to develop and cost twice as much to produce," Rolla says. "And we would have only sold half as many." DN

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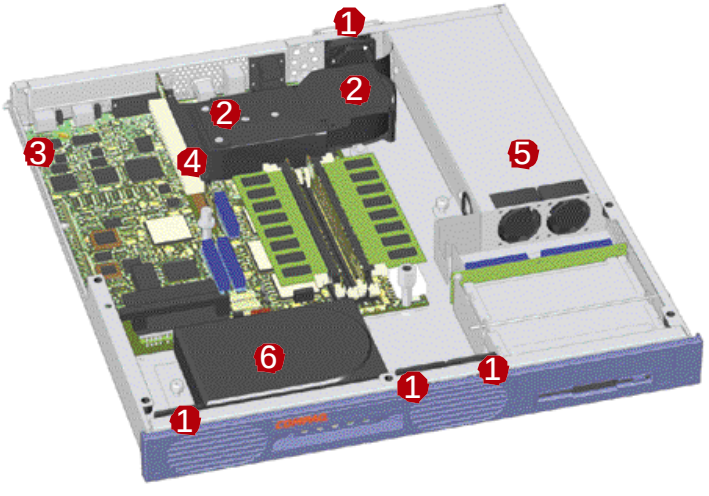

Global Sourcing on the DS101

1. **Fans** Japan/Taiwan
2. **CPU and fan** China/Taiwan
3. **Chassis** Hong Kong/Mainland China
4. **PCI riser card** Scotland
5. **Power Supply** China/Taiwan/Mexico
6. **Heatsink** U.S.

Compaq specs components and parts for the DS10L from all over the world. Key to managing this effort: Constant communication via email, voice mail, and FAX; weekly, late-night conference calls; and a dedicated FTP site for dropping CAD drawings, database files, and other documents.